

The thorax (figs. 7 and 8) is arched, broadest in front, without any marked incision between the meso- and metanotum; the mesonotum itself is, when seen from above, very broadly oval, almost circular, rather broader in front and somewhat flattened behind. Figs. 7 & 8 give outlines of the thorax, seen laterally and from above. The legs are of moderate length, the hinder ones somewhat the longest. The scale or knot (fig. 6) is heart-shaped, flat behind, slightly arched in front, and with a few stiff, slightly diverging hairs at the upper angles. The length is about two thirds of an inch.

## DESCRIPTION OF PLATE VIII.

- |         |                             |  |
|---------|-----------------------------|--|
| Fig. 1. | <i>Camponotus inflatus.</i> | Head, seen from above, × 20.                   |
| 2.      | „ „                         | Antenna, „ × 25.                               |
| 3.      | „ „                         | Mandible, „ „                                  |
| 4.      | „ „                         | Labium, „ „                                    |
| 5.      | „ „                         | Maxilla, „ „                                   |
| 6.      | „ „                         | Knot, seen from behind „                       |
| 7.      | „ „                         | Outline of thorax, seen from the side,<br>× 9. |
| 8.      | „ „                         | Outline of thorax, seen from above, × 9.       |
- Pro.* Pronotum; *Mes.* Mesonotum; *Met.* Metanotum.

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On the Genus *Solanocrinus*, Goldfuss, and its Relations to recent *Comatulæ*. By P. HERBERT CARPENTER, M.A., Assistant Master at Eton College.

[Read June 3, 1880.]

(PLATES IX -XII.)

THE genus *Solanocrinus* was established by Goldfuss\* to include certain fossil Crinoids which he regarded as intermediate between the stalked *Pentacrini* and the free *Comatulæ*. He placed them among the stalked Crinoids, however, on account of their usually having a centrodorsal piece somewhat deeper than that of the few recent *Comatulæ* known to him; so that he was led to regard it as a short stem composed of but few joints. Between this so-called

\* 'Petrefacta Germaniæ,' i. p. 162.

stem and the united radials he found (in most of his specimens) five basal pieces of variable size (Pl. IX. figs. 1, 2, Pl. X. figs. 14, 15). These are not visible in most recent *Comatulæ*, but were apparently represented in an exceptional species from the Indian Ocean, which Goldfuss referred to *C. multiradiata*, Lam.\* The specimen was dissected and described by him; but no similar one has since been found. It seems to have had basals analogous to those of *Solanocrinus*; but Goldfuss described its centrodorsal as consisting of one piece only, while he believed that of *Solanocrinus* to be made up of three or more ankylosed rings.

Although he recognized the great resemblance between this *Comatula* (which he supposed to be the type of many others) and the forms described by himself as *Solanocrinus*, yet he placed the latter among the stalked Crinoids for the reasons already given; though he mentioned at the same time that they were probably not "festgewürzelt" any more than the *Comatulæ* are.

Agassiz† erected the *Comatula multiradiata* of Lamarck into a new genus, *Comaster*, distinguished by its having the arms ramified instead of simply forked. He naturally included in this genus the many-armed specimen dissected by Goldfuss, who adopted this name for it‡, apparently under the impression that all the multiradiate *Comatulæ* possessed external basals. It was this character, however, and not the ramification of the arms, that he regarded as distinctive of the genus *Comaster*. This definition of *Comaster* was employed by Müller§, though, oddly enough, he ascribed it to Agassiz; and in this mistake he has been followed by most later naturalists. It must be remembered, therefore, that *Comaster*, Ag., is by no means the same as *Comaster*, Goldf. The latter type is the one with which we are especially concerned; and although Müller united it with *Solanocrinus*, Goldfuss continued to regard it as distinct on account of the supposed differences between their respective centrodorsal pieces; and expressly stated that it had no fossil representatives. Both were distinguished from the ordinary *Comatulæ* by the presence

\* *Tom. cit.* p. 202.

† "Prodrome d'une Monographie des Radiaires ou Échinodermes," *Ann. des Scien. Nat.* 2<sup>e</sup> série, Zool. vii. p. 257.

‡ "Beiträge zur Petrefactenkunde," *Nov. Acta Acad. Leop.-Carol. Nat.-Cur.* xix. A. p. 348.

§ "Ueber den Bau des *Pentacrinus caput medusæ*," *Separat-Abdruck aus den Abhandl. d. Berlin. Akad.* 1843, p. 27.

of external basals. Subsequently, however, Müller gave up the genus *Comaster* (and *Solanocrinus* with it), chiefly because he had examined several species of free Crinoids without ever finding one with external basals\*. But Roemer†, a few years later, while uniting *Solanocrinus* and *Comaster*, retained the latter name as designating a type, distinct from *Comatula* with no external basals. About the same time d'Orbigny‡ threw all these three, together with "*Glenocrinus*, Goldf." (i. e. *Glenotremites*), into one genus, to which he assigned Lamarck's name *Comatula*:—"Nous y conservons les espèces pourvues de cinq petites pièces basales, entre les cinq pièces brachiales et la pièce centrale épaisse, portant dix séries de ramules égales. Cinq bras bifurqués une ou plusieurs fois. Le calice mal observé par M. Goldfuss a servi à l'établissement de ses genres *Glenocrinus* (*sic*) et *Solanocrinus*."

D'Orbigny was rather hard on Goldfuss in accusing him of incorrect observation. As both of his specimens of *Glenotremites* consisted of the centrodorsal piece only (neither with ten rows of cirrhus-sockets), he could hardly have been expected to describe basals which he did not see. Lundgren§ has already pointed out that their presence was assumed by d'Orbigny, who, on the evidence before him, might, with equal justice, have referred *Glenotremites* to his next genus *Decameros*, by which he meant *Decacnemus*, Linck. He characterized this type by the absence of external basals; and to it he should have referred Lamarck's genus *Comatula*, as he did the *Antedon* of de Freminville and the *Alecto* of Leach. All the species of *Comatula* described by Lamarck are devoid of external basals, as d'Orbigny could have determined by a personal examination of them. For some unexplained reason, however, he referred them to *Comatula* as he defined it, namely with external basals.

D'Orbigny's peculiar redistribution of generic names was partly followed by Pictet||, who regarded *Glenotremites* as distinct and as presenting "special characters." He proposed a modification of d'Orbigny's nomenclature, in that he would retain

\* "Ueber die Gattung *Comatula*, Lam., und ihre Arten," Separat-Abdruck aus den Abhandl. d. Berlin. Akad. 1849, p. 8 (244).

† *Lethæa Geognostica*, iii<sup>te</sup> Auflage, 1851, Theil iv. p. 133, & Theil v. p. 177.

‡ 'Cours élément. de Paléontol. et de Géol. stratigraph.' 1850-52, vol. ii. (i.) p. 138.

§ "Om en *Comaster* och en *Aptychus* från Kopinge," Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, 1874, No. 3, p. 64, note.

|| 'Traité de Paléontologie,' vol. iv. p. 288.



the name *Comatula* only for the peculiar form described by Goldfuss as *Solanocrinus Jaegeri* (Pl. XI. fig. 24), in which there is a closed circlet of basals, all species with an incomplete basal ring being then referred to *Solanocrinus*. As I hope to show later on that *S. Jaegeri* is the stemless head of a *Pentacrinus*, and not a *Comatula* at all, I cannot accept Pictet's classification, which has not found favour with any of my predecessors.

Müller's views reappeared in 1860 in Bronn's 'Thierreich'\*, in which *Solanocrinus*, *Comaster*, and *Comatula* were united under one name, *Comatula*. Two years later Dujardin and Hupé† removed the first two types again under the single name *Comaster*; while in 1866 Lovén‡ reunited *Comaster* and *Comatula* on the ground that Goldfuss's analysis of the calyx of the former could not be correct. He suggested that the so-called "basals" of Goldfuss were merely the angles of the first radials; but this cannot have been the case, if any reliance is to be placed on Goldfuss's figure of the dissected calyx. Lundgren§ identifies *Comaster* with *Solanocrinus*, but prefers the former name, which he has given to a Cretaceous type presenting a considerable resemblance to the Jurassic forms described by Goldfuss as *Solanocrinus*. De Loriol|| thought (in 1868) that the presence of external basals might be sufficient to separate *Solanocrinus* from *Comatula*; but he has since united them under the pre-Lamarckian name *Antedon*¶. Quenstedt\*\* does not seem to consider *Comaster* as generically different from the other recent *Comatulæ*; and although he retains *Solanocrinus* as distinct from the latter, he remarks that there seems to be no essential difference between them.

Schlüter††, believing that the reasons which led Goldfuss to separate *Comaster* and *Solanocrinus* are no longer tenable, places them,

\* Band ii. Aktinozoen (1860), p. 233.

† 'Hist. Nat. des Zoophytes, Échinodermes' (Paris, 1862), p. 186.

‡ "Phanogenia, ett hittills okänt släkte af fria Crinoideer," Öfvers. af Kongl. Vetensk.-Akad. Förhandl. 1866, No. 9, p. 226.

§ *Loc. cit.* pp. 63, 69.

|| "Monographie des Couches de l'étage Valangien d'Arzier." Pictet, Matériaux pour la Paléontologie Suisse, 4<sup>e</sup> série, p. 84.

¶ "Monographie des Crinoides fossiles de la Suisse," Mém. Soc. Paléontol. Suisse, 1879, p. 254.

\*\* 'Petrefactenkunde Deutschlands,' Bd. iv. Asteriden und Encriniden, pp. 165, 171.

†† "Ueber einige astylide Crinoiden," Zeitschr. d. deutsch. geol. Gesellsch., Jahrg. 1878, p. 36.





the five that are situated interradially are the strongest (Pl. IX. fig. 1). Resting on their summits there appear the rounded ends of the prismatic basals that intervene between the lower angles of the radials and the upper surface of the centrodorsal. The distal faces of the radials do not rise directly from the margin of the centrodorsal, as in most recent *Comatulæ*; but they are separated from it by a portion of their dorsal surface that appears externally, as in *Pentacrinus* (Pl. XI. figs. 21 a, 23 a). I have elsewhere\* called this the "outer dorsal surface," in contradistinction to the "inner dorsal surface," that rests on the centrodorsal piece. The distal articular faces have a considerable slope inwards towards the vertical axis of the calyx, and have very distinct intermuscular notches in the middle of their upper borders that lead into the corresponding furrows of the ventral faces. There are also distinct interradiial notches between the muscle-plates of every two adjacent radials, which are continuous with the ventral interradiial furrows on the upper surface of the calyx.

A careful study of several specimens commonly referred to this type has shown me, not only that it exhibits a great amount of variation within what may fairly be regarded as specific limits, but also that many forms have been referred to it which differ from it in several points. Many of these differences are of the same nature as those which exist between the corresponding parts of various recent *Comatulæ*, and are always accompanied by variations in other characters that necessarily remain unknown for the fossil forms. The shape and relative proportions of the centrodorsal and radials vary considerably among the different species of recent *Comatulæ* (Pl. XII.); and one seems justified in concluding that variations of a similar character among the fossil forms may be taken as indicative of specific differences. In this way I hope to show that the *Comatula*-fauna of the White Jura of Wurtemberg was considerably more varied than has hitherto been supposed.

I have never seen any specimen of *Solanocrinus* precisely like the type of *S. costatus* (= *Antedon costata*, Pl. IX. fig. 1). There are, however, three specimens in the Woodwardian Museum and one in the British Museum, all from Nattheim, that resemble it very closely. Apart from irregularities in the development

\* "Preliminary Report upon the *Comatulæ* of the 'Challenger' Expedition," Proc. Roy. Soc. No. 194, 1879, p. 392.

of the basals, these four all differ in the height of the outer surfaces of the radials. In none of them does it reach the same relative proportion that it does in Goldfuss's figure (Pl. IX. fig. 1 *a*). There is also a considerable amount of variation in the proportions between the height and width of the articular faces, in the shapes of their muscle-plates, and in the relations between the diameter of the central funnel and that of the entire calyx. In Goldfuss's figure the upper ends of the muscle-plates are bluntly pointed, their superior margins sloping sharply downwards towards the intermuscular notch; but in three of the specimens before me they are more squared and nearly horizontal. Further, while the total diameter of my figure of the top of the calyx (Pl. IX. fig. 2 *b*) and the corresponding one of Goldfuss (Pl. IX. fig. 1 *b*) is the same, the diameters of the central funnel are very different in the two cases, being 16 millims. in fig. 2 *b*, but only 12 millims. in Goldfuss's figure (Pl. IX. fig. 1 *b*). This appears to be due to the distal faces of the radials of the Cambridge specimen having a rather less inward slope than those of Goldfuss's specimen.

There is yet another difference between the type and most of the specimens of *Antedon costata* which I have examined. In the former the cirrhus-sockets are regularly arranged in ten vertical rows. In the latter they are larger and much less regular, very much as in the specimen represented in Quenstedt's 'Encriniden' (pl. 96. fig. 32), which has squarish muscle-plates. On the other hand, his fig. 33 represents a specimen with a more regular centrodorsal and pointed muscle-plates; but it differs from the type in having no interrarial notches between the muscle-plates of contiguous radials. The specimen figured by Quenstedt in 'Der Jura,' tab. 88. fig. 10 (reproduced here on Pl. IX. fig. 4) is also different from the type, as the outer dorsal surface of the radials is greatly reduced. In this respect it is just at the opposite extremity of the series to Goldfuss's specimen, in which the exterior of the radials is unusually large (Pl. IX. fig. 1 *a*).

These differences are slight exaggerations of the kind of variation that one finds in recent *Comatulæ*; but they are insufficient to form the basis of specific distinctions. Curiously enough, one of the Cambridge specimens shows how variation may occur even in individual cases. It is slightly smaller than the others, with a more regularly ribbed centrodorsal (as in Goldfuss's specimen), and a relative width of the central funnel which is intermediate



between the two measurements given above ; while the shape of its muscle-plates is not constant, their upper ends being bluntly pointed in some cases (like Pl. IX. fig. 1 *a*), but more squared in others (like Pl. IX. fig. 2 *a*).

Diameter of the specimen figured (Pl. IX. fig. 2),  $13\frac{1}{2}$  millims. Total height  $10\frac{1}{2}$  millims. ; of the radials alone  $5\frac{1}{2}$  millims.

All the Cambridge specimens of *Antedon costata* agree with the type in the first radials having a considerable outer dorsal surface, so as to have been distinctly visible externally when the second radials were in position. The same is the case with all the adult specimens of *A. costata* figured by Quenstedt on pl. 96 of his 'Eneriniden,' and also in nearly all the allied species figured by de Loriol in his 'Fossil Crinoids of Switzerland.' In his 'Jura,' however (pl. 88. fig. 10), Quenstedt gives a small figure, which I reproduce here (Pl. IX. fig. 4), of a form in which the first radials have an unusually small exterior. The centrodorsal and the other characters of the radials resemble those of the type so far as can be judged from the figure, which is too small to be quite satisfactory. The specimen is interesting from its being a transitional form towards the next type, which must, I think, be regarded as distinct from *A. costata*.

II.—On pl. 51. fig. 36 of his 'Petrefactenkunde,' Quenstedt gives a small and indistinct figure of a Nattheim specimen that differs from the type species in the relations of the external surface of the radials. It does not continue the upward slope of the centrodorsal as in the type, but is nearly at right angles to it, so as to look almost directly downwards over the edge of the centrodorsal beyond which it projects, and not downwards and outwards. There is a small specimen in the British Museum from the same locality that agrees with Quenstedt's figure in this and other features, but differs from it in points of detail. The articular faces are much wider relatively to their height, and have a groove along their dorsal edges just below the fossa for the elastic ligament (Pl. IX. fig. 3). There are large basals at the angles of the calyx, and the centrodorsal is in the form of a truncated cone bearing ten rows of cirrus-sockets, but little traces of which are visible, as the specimen is somewhat worn. The division between the muscular and ligament fossæ has also become obliterated, as in most of the Nattheim specimens.

The specimen figured is 6 millims. high, with a diameter of 8 millims. I propose the name *Antedon truncata* for this type.

III.—This leads us on to another rather peculiar form, viz. that represented on pl. 88. fig. 9 of Quenstedt's 'Jura,' which I reproduce (Pl. IX. fig. 5). The centrodorsal is less ribbed than in the type of *A. costata*, and the cirrhus-sockets relatively larger but less numerous. The peculiarity of this form is that the radials have no external surface at all. Their articular faces rise directly from the upper surface of the centrodorsal, which bears the whole of their dorsal surfaces, no part of these appearing externally. They are more concealed than in any recent *Comatulæ*, in which their presence is usually just indicated by a line or a ridge between the articular surfaces and the centrodorsal. At the angles of the calyx are large basals partially separating the lower angles of the radials from the centrodorsal, but encroaching much more on the latter than on the former.

IV.—The next type to be considered is an imperfect specimen from Nattheim now in the British Museum (Pl. IX. fig. 6). The centrodorsal is essentially like that of *A. costata*, except that the cirrhus-sockets are not quite so regularly disposed in ten rows, and the ribs separating the rows are less prominent. The exterior of the radials is very low, and it is not convex, as is usually the case, but has an irregular groove running along it. Only three of the five radials remain; but only two basals are visible at the four angles corresponding to them (Pl. IX. figs. 6 *a*, 6 *b*), and they do not project outwards at all. They are the smaller ends of tapering rods which are seen sideways in fig. 6 *c*. Their larger central ends are partially concealed by matrix, but seem to have been in contact laterally, and to have received the lower ends of the ventral interradiar furrows which are seen descending towards them in fig. 6 *c*. The upper angles of the calyx are but slightly notched in correspondence with these furrows, and the intermuscular notches of the articular faces are also very slightly marked.

The diameter of this specimen is 14 millims. Total height  $9\frac{1}{2}$  millims.; of radials  $4\frac{1}{2}$  millims.

I propose to name the type *Antedon canaliculata*.

V.—The next form to be considered is *A. complanata*, by which name I distinguish a British-Museum specimen from Nattheim, which consists of the basals and radials only without any centrodorsal attached (Pl. IX. fig. 9). The radials have an external surface nearly as large as that of *A. costata*; and their distal faces slope very much, so that the calyx has a flattened appear-



ance; and nearly the whole of the great dorsal fossa is visible in a view of the calyx from above. The central pit in this fossa is rather less conspicuous than usual. The dorsal surface of the radial pentagon (fig. 9*b*) is singularly like that of *A. costata* and of the closely related (if not identical) *A. Gresslyi*, Etallon. There are five rod-like basals, which are barely in contact centrally, while their outer ends are just traceable on the exterior of the calyx (Pl. IX. fig. 9*a*).

Diameter 12 millims. ; height 4 millims.

This species has some resemblance to *A. Picteti*, de Loriol, but is more than twice its size, and is from the Middle Jurassic rocks, whereas *A. Picteti* is from the Neocomian.

VI.—We now come to a type which has given rise to a good deal of discussion. Among Goldfuss's figures of *Solanocrinus costatus* (tab. 1. fig. 7) there is one (fig. 7*c*) which does not agree at all either with the other figures or with Goldfuss's text. There are no external basals, and the radials have no outer surfaces, their articular faces rising directly off the centrodorsal, very much as in Quenstedt's specimen represented in Pl. IX. fig. 5. But Goldfuss's specimen had no external basals, which are present in the original of fig. 5. Goldfuss does not seem to have noticed that it scarcely agreed with his definition of *Solanocrinus*; but the peculiarity was observed by d'Orbigny\*, who supposed that the radials were absent as well as the basals, as he mistook their articular faces for a part of the centrodorsal. It is difficult to understand this error, as the resemblance of the five articular surfaces to those of the radials of *S. costatus* would almost seem to have been a sufficient guide. It is interesting, however, as showing how complete was the ankylosis of the radials and centrodorsal.

On this specimen d'Orbigny founded a new genus, *Comatulina*, which he defined as follows:—

“Ce sont des Comatules où il manque à la fois au calice les pièces brachiales et basales, où les bras s'articulent immédiatement sans intermédiaires à la pièce centrale pourvue de ramules.”

On this subject Pictet remarks:—“M. d'Orbigny a établi un genre *Comatulina* pour des calices dans lesquels les pièces basales et les radiales manqueraient, et les bras s'articuleraient directement à la centrale. Cette description semblerait indiquer un genre bien tranché; mais M. d'Orbigny prend pour type le *S. costatus*, Goldf., qui a évidemment des petites pièces basales.”

\* *Op. cit.* ii. (i.) p. 139.



In this case Pictet has entirely failed to follow d'Orbigny's meaning. The type of his *Comatulina* is *not* the *S. costatus*, Goldf., although figured under that name in the 'Petrefacta Germaniæ'; for it differs from the type in two important points. Further, d'Orbigny expressly named the individual figure (tab. 1. fig. 7, *c*) to which his description referred; and by this means he naturally might be considered to have guarded himself against misapprehension. Messrs. Dujardin and Hupé followed Pictet's lead, speaking of him as "reconnaisant que d'Orbigny qui prenait pour type le *Sol. costatus*, et qui le nommait *Comatulina* lui donnait une caractéristique inexacte en lui refusant à la fois les pièces brachiales et basales et en prétendant que les bras s'articulent, sans intermédiaire, à la pièce centrale."

The last error is easily comprehensible, as I have shown above; while the absence of basals is a fact, though Dujardin and Hupé seem to have recognized no more than Pictet did, that Goldfuss's tab. 1. fig. 7 *c* differs from the adjacent figures of *S. costatus* in this essential character.

There are two specimens in the British Museum which are very like the figure in question, one from Nattheim and the other simply labelled "White Jura, Wurtemberg." The former (Pl. IX. fig. 8) is the larger, and has a flatter calyx, *i. e.* the slope of the articular faces is less steep. The central pit for the elastic ligament in the great dorsal fossa is less marked than in the second specimen, which is almost exactly like Goldfuss's figure, except that its centrodorsal is a little lower and less tapering. I do not think, however, that either of these can be considered specifically different from Goldfuss's specimen. At one angle of the Nattheim specimen there is a slight irregularity of growth (Pl. IX. fig. 8 *b*), for the two contiguous radials show a small amount of outer surface which slopes away laterally and disappears rather sooner on one side than on the other. This is an abnormal condition of some interest, from its relation to d'Orbigny's other type, *Decameros*, which will be considered immediately. Figs. 8 *a* and 8 *b* show the other characters of this type, for which I propose the name *Antedon d'Orbignyi*, as d'Orbigny was the first to recognise its peculiarities.

Total height  $6\frac{1}{2}$  millims.; of radials 3 millims.

VII.—The Woodwardian Museum contains a specimen from Nattheim of the *Comatulina* type, which differs considerably both from

d'Orbigny's original species and from that just described. The distal faces of the radials have a very steep slope (Pl. IX. fig. 7 *b*), so as not to enter very largely into the ventral aspect of the calyx (fig. 7 *a*). The centrodorsal is a thick disk, the sides of which bear several vertical rows of two, or occasionally of three sockets each; but there are none at all on the pentagonal dorsal surface, which is nearly flat.

Diameter  $8\frac{1}{2}$  millims. Height  $5\frac{1}{2}$  millims.; of radials 3 millims.

I believe this species to be an *Actinometra*, and propose to call it *Act. wurtembergica*. Although the centrodorsal is relatively thicker than it usually is in this genus, it is scarcely more so than in the recent *Act. stelligera* (Pl. XII. fig. 26), while its dorsal surface is entirely free from cirrhi as in the typical forms of the genus. The proportions of the articular faces of the radials, their steepness, and the consequent width of the central funnel are also characteristic of *Actinometra*. They are not quite as steep as in *Act. lineata* from Bahia (Pl. XII. fig. 27 *a*), in which the calyx is remarkably "wall-sided;" but the same is the case with one or two recent species, which are nevertheless undoubted *Actinometræ*.

As with most Jurassic *Comatulæ*, the boundary between the ligamentous and muscular fossæ seems to have been very slightly marked and to have become altogether lost. This feature, which always indicates the small size of the muscular fossæ, together with the relative lowness of the articular faces, is very characteristic of recent *Actinometræ* (Pl. XII. fig. 26); and it is very rare in the recent species of *Antedon*. Almost the only one in which it appears is *Ant. macrocnema*, from Sydney Harbour, which in this, as in other respects, presents so many points of resemblance to the Jurassic *Comatulæ*. The majority of Cretaceous and recent *Antedons* are of a type like that of *Ant. antarctica* (Pl. XII. fig. 29 *a*), with high articular faces and large well-marked muscle-fossæ, which are separated from the ligament-fossæ by a distinct ridge. It is therefore interesting to find most of the earlier *Antedons* approaching *Actinometra* in this respect. There are however, a few exceptions. Thus, in *Ant. Tessoni* (Pl. X. fig. 10), *Ant. decameros* (fig. 11), and *Ant. scrobiculata* (figs. 17 *a*, 18 *a*) the boundary ridge between the ligamentous and muscular fossæ is distinctly visible. De Loriol\* has figured it in this last species (pl. xx. figs. 11 *b*, 12 *b*), and also in *Ant. Gresslyi*

\* 'Swiss Fossil Crinoids,' *loc. cit.*



(pl. xx. fig. 4 a), *Ant. Gillerioni* (pl. xx. fig. 7 b), and *Ophiocrinus Hyselyi* (pl. xxi. figs. 10 a, 10 b); but he does not seem to have been aware of its meaning; for he neither mentions it, nor does he ever mention any ligament-fossæ except the large dorsal one below the articular ridge.

VIII.—We now come to a type of *Comatulæ* with which Goldfuss was unacquainted, although it is represented by the Cretaceous species *Hertha mystica*, described by Hagenow\* in 1840, and by most recent *Comatulæ*. It was described by d'Orbigny † as follows under the name of *Decameros*:—"Nous reservons ce nom aux Comatules dont le calice se compose d'une pièce centrale épaisse, et sur laquelle s'appliquent immédiatement cinq pièces brachiales, sans pièces basales." In addition to the recent *Antedon* and *Alecto*, two fossil species were referred by d'Orbigny to this type, and *Hertha* was subsequently added by Pictet. But as their nomenclature was incorrect, the classification which they proposed, although a sound one and based on good morphological principles, was never really adopted. Quenstedt, indeed, makes no mention of it except that he regarded forms without external bases as monstrosities of *Ant. costata*. Thus, after describing this species on p. 58 of his 'Jura,' he continues—"Es scheinen auch Missbildungen vorzukommen; der fig. 11 (tab. 88) fehlen z. B. die Zwischenradiale, und die Radialglieder zeigen aussen eine breitere glatte Fläche, aber die poröse Säule bleibt noch." It is strange that he had not only overlooked the descriptions of d'Orbigny and Pictet respecting the deficiency of basals in certain *Comatulæ*, but that he was not then aware that this was the condition of nearly all the recent *Comatulæ* then known (*Comaster*, Goldf., being of course excepted). It seems, however, to be comparatively rare among the fossil species, most of which have the basals more or less developed externally, though they are occasionally wanting at one or two angles of the calyx‡. There are two specimens in the British Museum which are devoid of external basals, and must therefore be ranked with the *Decameros*

\* "Monographie der Rügen'schen Kreide-Versteinerungen. ii. Abtheil. Radiarien und Annulaten," Neues Jahrb. f. Mineralog. 1840, p. 664.

† *Op. cit.* ii. p. 138.

‡ E. g. *Ant. æquimarginata*, *A. lenticularis*, *A. canaliculata* (Pl. IX. figs. 6 a, 6 b). No external basals have been described in *A. italica*, while they do not appear in de Loriol's figures of *A. Picteti*, *A. infracretacea*, and others, though he says they are "à peine apparentes au dehors."



of d'Orbigny. Neither of them is identifiable with Quenstedt's "Missbildung" ('Jura,' tab. 88. fig. 11), while they are also different from one another (Pl. X. figs. 10, 11). The larger one, *Antedon Tessori* (fig. 10), belongs to the Tesson collection, in which it was received under the name of *Millericrinus regularis*, d'Orb., a somewhat singular name, as d'Orbigny's description\* of this species commences "sommet inconnu"! The specimen in question is from the Argile de Dives (Oxford clay) of Vache Noire, and is therefore older than the Nattheim *Comatulæ* from the upper beds of the White Jura. Nevertheless it has a most striking general resemblance to the type of *Antedon costata* (Pl. IX. fig. 1 a), except for the radials resting directly on the centrodorsal all round, instead of being cut off from it by basals at the angles. They have a large external surface continuing the upward slope of the centrodorsal, and looking downwards and outwards just as in *Ant. costata*, while the appearance of the ventral aspect of the calyx is very much the same in both species. *Ant. Tessori* is distinguished, however, by the nature of the articular faces of the radials. These have much more distinct ridges, separating the muscular fossæ above from the ligament-fossæ below, than I have seen in any specimen of *Ant. costata*; while the ligament-fossæ themselves are separated by a groove, proceeding downwards from the intermuscular notch and ending round the opening of the axial canal. These characters alone are sufficient to indicate the specific distinction of this type.

Diameter 12 millims. Height  $8\frac{1}{2}$  millims.; radials  $4\frac{1}{2}$  millims.

IX.—The smaller "*Decameros*" in the British Museum is from Nattheim, and its ventral aspect much resembles that of *Ant. Tessori* and *Ant. costata*. But the external surface of the radials (Pl. X. fig. 11) is small, and looks almost directly downwards, as in *Ant. truncata* (Pl. IX. fig. 3). Although I fully believe basals to be wanting at all the angles of the calyx, I cannot speak with absolute certainty about it; for there are some suspicious-looking lines at one angle that might be the sutural lines of a small basal. Were they so, this species would be brought still nearer to *Ant. truncata*, from which, however, it differs altogether in the nature of the articular faces. They are higher in proportion to their width, and have well-developed muscle-fossæ separated distinctly from the ligament-fossæ, as in *Ant. Tessori*; but the mode of separation is different. In *Ant. Tessori* the fossæ are separated by a

\* 'Crinoïdes,' p. 88

nearly horizontal ridge (Pl. X. fig. 10); but in *Ant. decameros*, as I will call the Nattheim specimen, the ligament-fossæ have a convex upper border (Pl. X. fig. 11), behind and inside which are the muscle-plates. Consequently these stand out much more independently of the ligament-pits than those of *Ant. Tessonii* do.

Diameter  $8\frac{1}{2}$  millims. Height  $7\frac{1}{2}$  millims.; radials  $3\frac{1}{2}$  millims.

X.—The Woodwardian Museum contains three specimens, all from Nattheim, of another small *Antedon*, which differs considerably from either of the species just described. The radial pentagon is much depressed, as in *Ant. complanata* (Pl. IX. fig. 9 a), and its external surface slopes rapidly downwards and inwards until it meets the low centrodorsal. The latter is thus of much less diameter than the radial pentagon, especially in the specimen represented in Pl. X. fig. 13. Neither of the three (Pl. X. figs. 12, 13) show external basals; and in this respect they differ from certain somewhat similar forms that have been already described elsewhere. Among these are *Ant. Picteti* and *Ant. infracretacea* of de Loriol, already referred to as having scarcely visible basals. The first of these, from the Étage Valangien of Switzerland, differs from the Woodwardian specimens (*Ant. depressa*) in being a good deal smaller, and in the somewhat different proportions of the radials, though the same general features appear in both. Besides *A. Picteti* has only ten cirrhi or even fewer; while there may be three rows of sockets in *Ant. depressa* (Pl. X. fig. 12). This last has a general resemblance to fig. 35 on Taf. 96 of Quenstedt's 'Encriniden,' which he calls the young of *Ant. costata*; while, except for the absence of basals and of a transverse ridge on the concave lower surface of the centrodorsal, fig. 13 on Pl. X. is not unlike Quenstedt's figures of *Ant. sigillata* (tab. 96. figs. 49, 50). The original has only one row of cirrhus-sockets of the usual *Solanocrinus* character, viz. oval-oblong in shape with a transverse articular ridge pierced by the opening of the cirrhus-canal. There is, however, no distinct indication of this in either of Quenstedt's figures, which may be due either to the imperfect preservation of his specimens or to their immaturity.

Diameter of largest specimen 7 millims. Height  $4\frac{1}{2}$  millims.; radials  $2\frac{1}{2}$  millims.

XI.—The designation *sigillata* has been given by Quenstedt to those rare specimens which show a perforated articular facet on the lower surface of the centrodorsal, thus retaining, as suggested by him, more or less permanent traces of their larval condition.



These immature *Antedons* occur at both Nattheim and Schnaitheim in the same beds (Weisser Jura,  $\epsilon$ ) as *A. costata*. I do not think, however, that they can be identified with that species, chiefly on account of the differences in the characters of the radials. A side view of *A. costata* (Pl. IX. figs. 1 *a*, 2 *a*) shows not only the external surface of the radials directly above the centrodorsal, but also their distal articular faces, that are set at a very obtuse angle to this surface. In *Ant. sigillata*, on the other hand, the outer surface of the radials is relatively far larger than in *Ant. costata*; but the distal articular faces, are set on to it at such a much less obtuse angle that little or nothing is visible of them in a side view ('*Encriniden*,' tab. 96. fig. 49). I know nothing like this condition among the recent *Comatulæ*, though an apparent approximation to it is seen in Quenstedt's figures 35 and 56, described as the "young" of *Ant. costata* and *Ant. scrobiculata* respectively; but these figures are not distinct enough for me to make this out with certainty. They also resemble *Ant. sigillata* in the relatively small size of the basals, which is another point of difference between it and *Ant. costata*. Many of these smaller varieties require much more illustration than it was possible to give them in the necessarily crowded plates of Quenstedt's admirable atlas.

XII.—*Antedon aspera* is one of these incompletely known forms. The calyx seems to be rare, though portions of the arms have been found in the Swiss Jura by de Loriol and others\*. It was originally described and figured by Quenstedt in the 'Jura' as *Solanocrinus asper*, its surface being roughened by fine tubercles. The same writer has again figured his original specimen in his '*Encriniden*,' giving a different view of it from that represented in his earlier figure. No external basals are present in the latter, and there is no mention of them in the accompanying descriptions. But in the later figure fairly large basals are represented, while Quenstedt also describes and illustrates a tetra-*radiate* form with *five* basals, so that they may be regarded as characteristic of the type. Figures 19 *a*, *b*, *c* on Pl. XI. represent three views of a small specimen from Streitberg (White Jura, *a*), in the Münster collection of the Woodwardian Museum, that appears to be identical with Quenstedt's species. The centrodorsal is a pentagonal disk with its angles produced into five strong ribs, each of which is marked by a distinct groove. The grooves start from near the

\* The literature of this species may be found on p. 257 of de Loriol's '*Crinoides Fossiles de la Suisse*,' part iii. (1879).



centre of the dorsal surface of the piece, pass over its edge and along the sides towards the ventral surface, but end at different levels (Pl. XI. figs. 19 *a*, *c*). It is very difficult to say whether basals are present or not. There are processes at two of the angles which might be taken for basals (fig. 19 *a*); but these are absent at a third and difficult to make out in the other two. The diameter of the radial pentagon is considerably greater than that of the centrodorsal; its wide outer surface is very rough and uneven. The general shape of the articular faces resembles that of some specimens of *A. scrobiculata* (Pl. X. fig. 18 *a*), but there are one or two peculiar features. The transverse articular ridge present in nearly every *Antedon* is absent, but in place of it a strong process runs from each side towards the middle line and then stops abruptly (Pl. XI. fig. 19 *a*). Just above the inner ends of these two processes is a large transversely oblong hole, which I take to be the central canal; but if so, there is no ligament-pit below it, while both are represented in the later figure of Quenstedt's specimen. A short bony bar bridges over this large opening on the ventral side and unites the two large triangular muscle-plates, the outer edges of which are thick and everted as in *A. scrobiculata*. This gives a peculiar appearance to the ventral surface (Pl. XI. fig. 19 *b*), the furrows between the apposed muscle-plates converging to a large pentagonal opening, which is evidently more or less artificial; its angles correspond with the bony bars above the large openings in the articular faces.

Diameter 6 millims. ; height  $5\frac{1}{2}$  millims. ; radials  $3\frac{1}{2}$  millims.

### XIII.—*ANTEDON SCROBICULATA*. (Pl. X. figs. 14–18.)

Goldfuss, Quenstedt, and de Loriol\* have described under the above specific name a number of *Antedons* from different horizons, which all resemble one another in certain points, but differ very much in others. They all differ from *A. costata* in the distal faces of the radials being higher than wide, the reverse being the case in *A. costata*. The Münster collection of the Woodwardian Museum contains three specimens of this species, two of them authenticated in Münster's own handwriting. One character common to them and to the other known examples of the species is the shape of the central funnel. This is not a simple pentagon,

\* 'Swiss Crinoids,' p. 255 (with literature).

as in *A. costata*, but a relatively narrower opening\* in the form of a star with five blunt petaloid rays. These rays correspond to the interradian angles of the calyx, where there is no notch between the muscle-plates of adjacent radials; but the upper edge of each plate rises considerably from its inner to its outer margin, where it meets its fellow of the next radial (Pl. X. figs. 17*a*, 18*a*). The edges of the muscle-plates are here somewhat thickened and everted, so as to produce the more or less petaloid figure surrounding the central funnel (fig. 17*b*). The ventral inter-radial furrows start from the points of the figure and lead down into the interior of the calyx; the ventral radial furrows, on the other hand, start from shallow notches in the re-entering angles of the figure. These notches separate the inner ends of the two muscle-plates of the same radial, but are not continued down on to the articular surfaces, except as very faint grooves.

This eversion of the muscle-plates at the top is especially marked in fig. 15 on tab. 81 of Quenstedt's 'Jura,' and in Pl. X. fig. 18*a*; while it is much less distinct in the specimen, from a different locality and horizon, represented in fig. 34 on tab. 51 of the 'Petrefactenkunde,' so that the opening of the central funnel is more nearly pentagonal and less distinctly stellate. In this specimen, too, the basals are smaller than usual, though there is a considerable range of variation in this respect†. In some forms they project prominently beyond the level of the radials, the so-called *Solanocrinus Bronnii* of Münster‡ showing this most distinctly (Pl. X. fig. 16). I am disposed to follow Quenstedt's example and to merge this species in *A. scrobiculata*, the range of variation in which renders the isolation of Münster's species rather difficult.

The numerous varietal forms which have been referred to *A. scrobiculata* (and all agree in the characters already mentioned) differ very considerably in the appearance of the outer surface of the radials and in the shape of the centrodorsal. Thus, one of Goldfuss's specimens (Pl. X. fig. 14) had a very deep centrodorsal, with the high outer surfaces of the radials much narrowed below by the large size of the basals. But a Woodwardian specimen with a similarly deep centrodorsal has a calyx with characters intermediate between those of Goldfuss's two varieties

\* The opening of the original of fig. 17*b* is both wider and more pentagonal than usual.

† Compare figs. 15-17, 19 & 21 on Plates X. and XI.

‡ Beitrage zur Petrefactenkunde, p. 101, Taf. xi. fig. 7.



represented on Pl. X. figs. 14, 15. On the other hand, the centrodorsal may be exceedingly shallow and the exterior of the radials very low, as in the Woodwardian specimen shown in Pl. X. fig. 17*a*, and in some of the forms from the Swiss Jura figured by de Loriol. In tab. 96. figs. 52–55 of his ‘Encriniden,’ Quenstedt represents four different calices that are all alike in their general features, but differ in minor points, such as the height of the outer surface of the radials and the relative prominence of the basals. The centrodorsal is of much the same size and shape in all of them, in no case reaching the length shown in Pl. X. fig. 14, while it is never so small as in the original of Pl. X. fig. 17*a*. The total height of this specimen is 7 millims., that of the radials 5 millims., and its diameter 8 millims.; while in the other perfect (Woodwardian) specimen already mentioned, with slightly smaller radials, the depth of the centrodorsal is doubled, viz. 4 millims. instead of only 2 millims.

*A. scrobiculata* differs considerably from *A. costata* in the size and disposition of its basals, which Quenstedt\* has well described as follows:—“Man findet auf den untern Kelchflächen (tab. 96. fig. 57) fünf nach den Ecken strahlende Rinnen, welche die Unterseite der Basalia bilden, die sich um den grossen Nahrungskanal zur einer Fläche ausbreiten und so eine festere Unterlage der Radialglieder bilden. Die Fläche ist bald eben (fig. 57), bald ansehnlich vertieft (fig. 58).” A comparison of the side and dorsal views of the radial pentagon, as represented in figs. 18*a* and 18*b*, gives a very good idea of the basals as prismatic rods, the dorsal surface of which is almost entirely occupied by a groove with plaited sides. But the actual basal pieces themselves are rather wider than these grooves, which does not appear in Quenstedt’s description of them, though it is just traceable in his figures. This is seen still more clearly in the basals of *Act. cheltonensis* (Pl. XI. fig. 20*b*), which have far more distinctly plaited grooves than those of *Ant. scrobiculata*. Both these last-mentioned species differ from *Ant. costata* in the confluence of the inner ends of the basals, so as completely to separate the radials and centrodorsals for some little way round the opening of the central funnel. In *Ant. costata*, however, the central ends of the basals do not seem to meet one another at all†, while the same might be said of *Ant. complanata* (Pl. IX. fig. 9*b*).

\* Encriniden, p. 179.

† Encriniden, tab. 96. figs. 29, 44.



XIV.—*ACTINOMETRA CHELTONENSIS*, n. sp. (Pl. XI. fig. 20.)

This fossil consists of the united radials and basals of what must have been a very large *Actinometra*. The five basals are united by their broader inner ends, so as to conceal the central half of the radial pentagon (fig. 20*b*). A deep linear-oval groove is excavated along the underside of each of them, terminating just short of the rounded end which appears externally (fig. 20*a*). The sides of the groove are marked by very distinct cross ridges and furrows, which do not quite reach either end of it. The outer portion of the dorsal surface of the radials (*i. e.* that portion which would have appeared externally when the centrodorsal was *in situ*) is rather narrow, and looks almost entirely downwards. Hence, although it appears on the dorsal aspect of the calyx outside a line drawn round the points of the basal star (fig. 20*b*), but little of it is seen in a side view (fig. 20*a*), except where its flanks are turned upwards above the rounded ends of the basals. The articular faces are trapezoidal in shape, and the pit in the great dorsal fossa, which lodged the chief mass of the elastic ligament, is unusually long and narrow, somewhat as in *Ant. Gillerioni*, de Loriol. The transverse articular ridge above it is rather large, and the opening of the central canal which pierces it much elongated transversely, and also slightly constricted in the centre. This indicates that the secondary basal canals, by the union of which the axial canal of each ray is formed, did not in this species converge quite so rapidly as in other *Comatulæ*; so that it presents a slight approach to the condition found in *Encrinus*, in which genus they do not unite in the first radial at all, but open by two separate apertures on its distal face. The muscle-plates are rather small, and separated by a wide but shallow notch; they are marked off from the ligament-fossæ by faint cross ridges, which run inwards from the sides, and then turn downwards towards the rim of the opening of the axial canal, so as to leave a slight groove between them (fig. 20*b*).

Diameter 9 millims. ; height 3 millims.

*Locality.* The Inferior Oolite, Cheltenham.

*Remarks.* This specimen was found by the Rev. P. B. Brodie, M.A., F.G.S., who has kindly placed it in my hands for description. The relative width of the articular faces and the condition of the muscle- and ligament-fossæ indicate this type as an *Actinometra*, though the articular faces are more sloping than in most species of the genus. There are, however, one or two similarly aberrant species in the 'Challenger' collection.

*Act. cheltonensis* is interesting as being one of the two oldest known *Comatulæ*, so that *Act. Mülleri*, of the Bath Oolite, must be disestablished. Since describing this species\* I have obtained some information respecting the "*Solanocrinus*" mentioned by Mr. Charles Moore, F.G.S., in the 'Geological Magazine' for 1875. This fossil was found by Mr. Moore in the Inferior Oolite at Dundry, and is an unmistakable *Antedon*, as I have learnt from a drawing of it which he kindly sent me. It is quite a different type from *Act. cheltonensis*, having high radials more like those of *Ant. antarctica* (Pl. XII. fig. 29a). It is very interesting to find that while most of the Jurassic *Comatulæ* are rather synthetic in their character, the two genera *Antedon* and *Actinometra* were yet distinctly differentiated at the earliest period at which we have any record of their appearance.

XV.—We have now to consider an interesting fossil that was figured by Goldfuss† under the name of *Solanocrinus Jaegeri*. He describes it as resembling *S. scrobiculata* in external form, but as differing essentially, "durch seine Beckenglieder, welche so breit sind dass sie auf der ganzen Gelenkfläche zusammenstossen, und hier fünf ausstrahlenden Furchen zur Aufnahme der Säule bilden. Die Säule ist nicht bekannt." Figures 24, *a*, *b*, & *c*, on Pl. XI., are copied from Goldfuss's representations of this very elegant type, the difference between which and the *Comatulæ* represented by him (Pl. IX. fig. 1, Pl. X. figs. 14, 15) is self-evident. In the latter the basals are small and not in contact with their fellows for the whole length of their sides; whereas in *S. Jaegeri* they form a completely closed ring beneath the radials (figs. 24, *a*, *c*). This was recognized by Pictet‡, who suggested that *S. Jaegeri* should be removed from *Solanocrinus*, as typified by *S. costatus* with small basals, and that it should be placed in a separate genus (*Comatula*), which he had defined as follows:—"Les *Comatula*, Lamarck (*Astrocoma*, Blainv.), ont les bras bifurqués une ou deux fois. Le calice est composé d'une pièce centrale, de cinq petites pièces basales et de cinq brachiales qui alternent avec les basales. Il porte dix séries de ramules égales."

This classification is a very singular one. Lamarck's name *Comatula* had been already adopted by d'Orbigny for the *Solanocrinus* group characterized by the presence of external basals. These are not present in any of Lamarck's original specimens,

\* Quart. Journ. Geol. Soc. vol. xxxvi. p. 54.

† *Op. cit.* p. 168, Taf. I. fig. 9.

‡ *Op. cit.* p. 288.



while no recent *Comatulæ* are known with a complete basal circlet like that of *S. Jaegeri*. According to Pictet's proposed classification, therefore, the name originally established by Lamarck for several recent forms without any external basals would have passed to a single fossil specimen that I shall show directly to be the head of a *Pentacrinus*, and not a *Comatula* at all!

Schlüter speaks of it as abnormal, and not belonging to the type of *S. costatus* and *S. scrobiculatus*, but does not offer any opinion as to its real nature. This, however, is discussed by Quenstedt, though with a singularly unfortunate result. A small specimen from Nattheim was referred by him to this species and described, with figures, no less than three times. It was first noticed in the 'Petrefactenkunde' (p. 717), with the remark that the basals were scarcely visible (!), and that the lowest part consisted of a large smooth stem-joint (Pl. XI. fig. 22). His figure (tab. 51. fig. 33) shows no basals between this stem-joint and the radials, although in Goldfuss's specimen they were quite large (Pl. XI. fig. 24, *a, c*). The figure in the 'Jura,' however (tab. 88. fig. 12), shows small points in this position (Pl. XI. fig. 22 *a*); while Quenstedt seems to have recognized their want of resemblance to the basals of Goldfuss's original specimen; for he states (p. 723) that the smooth stem-joint below them had been regarded by Goldfuss as composed of five anchylosed basals. The figure given in the 'Jura' is reproduced in the 'Encriniden' (tab. 96. fig. 51), with the remark, "Zwar weicht die Goldfuss'sche Zeichnung vielleicht nicht unwesentlich ab, allein die Hilfsarme fehlen ihr auch, und das genügte mir um nicht immer gleich wieder neue Namen zu schöpfen." Quenstedt, therefore, while recognizing the difference between his specimen and the *S. Jaegeri* of Goldfuss, seems to have thought the absence of cirrhi from both of them a sufficient reason for not separating them specifically. I shall show, however, that they are not only specifically but also generically different. The distinctive character of Goldfuss's type was the lateral union of the basals to form a complete ring beneath the radial pentagon. This was especially noticed by him, and fully illustrated by his excellent figures (Pl. XI. fig. 24, *a, c*), in which the sutures on the outside of the calyx between the individual basals are as distinct as they can well be. The basiradial suture is an obtuse angle, while the radials have a high outer dorsal surface and a high articular face with large muscle-plates, somewhat as in *Ant. scrobiculata* (Pl. X. figs. 14, 15, 17 *a*, 18 *a*), as remarked by Goldfuss. On the other hand,



the radials of Quenstedt's specimen, as he himself admits, are very similar to those of *Ant. costata*. The articular faces are very low (Pl. X. fig. 22 *a*) with small muscle-plates, while the outer dorsal surface is smaller than in *S. Jaegeri*; its lower margin is not angular but only slightly curved, and it is interrupted at the inter-radial angles by the small points that Quenstedt regards as basals. The radials of Quenstedt's specimen rest upon what he rightly interpreted as a "large smooth stem-joint;" and he supposes Goldfuss to have taken this for the anchylosed basals. This is certainly rather hard on Goldfuss, considering that he never saw Quenstedt's specimen at all, his own type differing considerably from that figured by Quenstedt\*.

It appears to me that while Quenstedt was undoubtedly right in supposing his specimen to have been detached from a stem, Schlüter's suggestion as to its being an immature form like *Ant. sigillata* is scarcely a satisfactory one. In the first place, as expressly remarked by Quenstedt, there are no certain traces of its having borne cirrhi, as would assuredly be the case were it a young and immature *Comatula*. On the other hand, if we suppose that cirrhi were once present, but that the centrodorsal has lost all traces of their sockets by the progressive deposit of new material upon its external surface, we are met by another difficulty. If this deposit has taken place it has been limited to the sides of the centrodorsal, which are usually the last parts to be affected by it, and it has not even closed up the central perforation, which in recent *Comatulæ* is obliterated very soon after the loss of the larval stem, the superficial deposit commencing here and gradually extending outwards.

The absence of cirrhi, together with the presence of a perforated articular facet on the under surface of Quenstedt's specimen (Pl. XI. fig. 22, *a, b*), seem to me to indicate clearly that it is the head and top stem-joint of a stalked Crinoid. There are some closely similar specimens in the British Museum, in which the presence of basals externally is very doubtful, as it is in the one figured by Quenstedt. I am inclined to think that these, as well as Quenstedt's specimen, should be referred to Étallon's genus *Thiolliericrinus*, good figures of which are given by de Loriol†. At any rate, they are not *Comatulæ*.

\* Since the above lines were written, I have seen Goldfuss's original specimen of *S. Jaegeri* in the magnificent palæontological collection at Munich, and have satisfied myself as to the accuracy of his figures and description of it.

† Swiss Fossil Crinoids, pl. xviii. figs. 8, 9.

XVI.—The same may be said of the “*Solanocrinus Jaegeri*” of Goldfuss, which is nothing but the calyx of a *Pentacrinus* detached from its stem. This will be evident from a comparison of figs. 23 & 24 on Pl. XI. The three figures 24, *a*, *b*, & *c*, are reproductions of Goldfuss’s figures of *S. Jaegeri*; while figs. 23, *a*, *b*, *c*, which Dr. Carpenter has kindly permitted me to publish, represent the corresponding parts of *Pentacrinus Wyville-Thomsoni*, dredged by H.M.S. ‘Porcupine’ in 800 fms. off the coast of Portugal in 1870. This species has a complete basal cirlet, as also have *P. Mülleri*, Lütken\*, and *P. Maclearanus* of the ‘Challenger’ dredgings. On our present classification both of these should be referred to *Cainocrinus*. This genus was established by Edward Forbes† for the reception of a small form from the London Clay, which resembles the well-known *P. briareus* and *P. asteria* (Pl. XI. fig. 21) in all essential points except the possession of a complete basal cirlet. The distinction has been retained and made more precise by de Loriol‡, probably in ignorance of the existence of two recent species of *Cainocrinus*. He defines *Pentacrinus* as differing from *Millericrinus* in having very small basals, which do not meet externally, and in the verticillar arrangement of the cirrhi. On the other hand, *Cainocrinus* has a complete ring of basals like *Millericrinus*, but a stem with verticils of cirrhi like *Pentacrinus*. I cannot, however, regard this classification as satisfactory; for even in those species of *Pentacrinus* which have an incomplete basal ring there is a great amount of variation in the extent to which the central ends of the basals are joined, and in the size of their outer ends which appear between the radials and the top stem-joint. The basals are least developed in *P. asteria* (Pl. XI. fig. 21), but there are all sorts of gradation between this condition and that of *P. Wyville-Thomsoni* and of the fossil *Cainocrinus*. A closed basal cirlet occurs in the fossil *P. Sigmaringensis*, Quenstedt§, referred by de Loriol to *Cainocrinus*, in *P. pentagonalis ferratus*||, and in the unnamed specimen¶ from Solzenhausen, in which Quenstedt specially describes a closed basal cirlet. He does not see any essential difference between *Cainocrinus* and *Pentacrinus*, and

\* “Om Vestindiens Pentacriner,” Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjöbenhavn, 1864, tab. iv., v.

† British Tertiary Echinoderms, p. 33.

‡ Swiss Fossil Crinoids, pp. 111, 112.

|| Ibid. tab. 98. fig. 135.

§ Encriniden, tab. 99. fig. 132.

¶ Ibid. p. 263, tab. 99. fig. 174.



therefore drops the former altogether. But he goes even further, as I do also, and includes in *Pentacrinus* all those forms which otherwise agree with the type but have no visible basals. One, for example, is the *P. cingulatus*, Quenstedt, = *Isocrinus pendulus*, Meyer\*. Another is the Forest-Marble specimen from Farley in Wiltshire, which was described by Goldfuss as *P. scalaris*. A third is the large Chalk *Pentacrinus* belonging to Mr. Willett's collection, which is figured in Dixon's 'Geology of Sussex' (1878 edition, pl. xix. 22). Another is the *P. pentagonalis personatus* from the Brown Jura, which is figured by Quenstedt (tab. 98. fig. 137) without any notice of its peculiarities. Lastly, there comes *P. Fisheri*, in which basals were described by Baily†. They are really, however, nothing but the first radials, the basals being absent from the exterior of the calyx. It might be thought that all these species without external basals should be separated from *Pentacrinus* and placed in the genus *Isocrinus*, von Meyer. In this way we should be making three genera out of one type, according as the basals are invisible externally (*Isocrinus*), or form an incomplete (*Pentacrinus*) or a complete ring (*Cainocrinus*). I do not think, however, that such a classification would be a sound one. On the same principle we should have to found a new genus for *Encrinus Cassianus*‡, in which "der perlschnurförmige Stiel deckt die tief eingesenkte Basis so stark, dass erst bei der genauesten Reinigung 5 winzige Dreiecke zum Vorschein kommen." Yet another new genus would be necessary for the reception of the tetramerous variety of *E. liliiformis* represented in tab. 107. fig. 5 of the 'Encriniden.' It has no external basals at all, but the radials rest directly on the top stem-joint. In the same way those forms of *Bourgueticrinus*§ in which the basal ring is incomplete, as in *Pent. asteria*, should be separated generically from the ordinary forms with a closed basal ring.

Seeing, then, that we have such a complete series from *P. Fisheri* and its allies through *P. asteria* (Pl. XI. fig. 21), *P. briareus*, and *P. decorus* to *P. Wyville-Thomsoni* (Pl. XI. fig. 23), *P. Jaegeri* (Pl. XI. fig. 24), and *P. Sigmaringensis*, a separation of either of the extremes from the rest of the series seems to me

\* "*Isocrinus* und *Chelocrinus*," Museum Senckenbergianum (Frankfurt, 1837).

† "Description of a new Pentacrinite from the Kimmeridge [*cf.* Oxford] Clay of Weymouth, Dorsetshire," Ann. & Mag. Nat. Hist. ser. 3, vol. vi. pp. 25-28, pl. i.

‡ Encriniden, p. 472.

§ *Actinometra*, p. 108, Trans. Linn. Soc. 2nd ser. Zoology, vol. ii.



a mistake, especially if we consider the corresponding conditions of *Bourgueticrinus*, *Encrinus*, and of *Comatula*. In the latter group basals may appear externally at some angles of the calyx and not at others. This is the case, for example, in *Ant. canaliculata* (Pl. IX. figs. 6, *a*, *b*) and in *Ant. complanata* (figs. 9 *a*, 9 *b*), in the latter of which the basals are somewhat similar to those of *P. asteria* (Pl. XI. figs. 21, *a*, *b*). Unfortunately we know of no *Comatula* with *Pentacrinus*-like basals which yet do not appear externally. But this is probably only because a view of the underface of the calyx is so rarely obtained. If this face could be exposed in any specimens of d'Orbigny's *Comatulina* or *Decamerros* (Pl. IX. figs. 7, 8, and Pl. X. figs. 10-12), it would doubtless be found that the basals were like those of *Ant. complanata* (Pl. IX. fig. 9) and *P. asteria* (Pl. XI. fig. 21), only rather shorter and not appearing externally as in these species. This is possibly the case in some of the species figured by de Loriol. I imagine it to be also the case in *Isocrinus pendulus*, *P. Fisheri*, and the other forms with no external basals, though it is, of course, possible that their basals may have undergone transformation into a rosette, as in recent *Comatulæ*. But this seems to me very unlikely. All the evidence we have goes to show that the basals of the Jurassic *Comatulæ* persisted, as in recent *Pentacrini*, without undergoing transformation into a rosette, and it is improbable therefore that this transformation should have occurred in extinct species of *Pentacrinus*.

It would be very interesting to determine, were it only possible, how and when the *Comatula*-stock first began to develop a rosette. As to *Ant. costata*, *Ant. scrobiculata*, and *Act. cheltonensis*, there can, I think, be little doubt that their basals are the embryonic ones. In the latter species there is obviously no rosette (Pl. XI. fig. 20 *b*), and the same applies to *Ant. scrobiculata* (Pl. X. fig. 18 *b*), in which the margins of the under surfaces of the basals are faintly plaited. This feature is more marked in a specimen in the British Museum figured in König's 'Icones' as *Symphytocrinus florifer*, in obvious reference to the petaloid figure formed by its basals, which expand rather more between their inner and outer ends than do the corresponding parts of the Cambridge specimen. It forcibly recalls the plaiting on the underside of the basals of *Pentacrinus*, which may be almost separate (Pl. XI. fig. 21 *b*), completely united (figs. 23, 24), or in an intermediate condition like those of *Ant. scrobiculata* (Pl. X. fig. 18 *b*) and *Act. cheltonensis* (Pl. XI. fig. 20 *b*). We may therefore, I think, consider

it certain that the external basals of these Jurassic *Comatulæ* are homologous with those of the larval *Antedon* and of *Pentacrinus*; and I have given reasons above for believing the same to be the case with the forms described as *Decameros* and *Comatulina* by d'Orbigny.

In some, at any rate, of the Cretaceous *Comatulæ* the larval basals appear to have persisted without metamorphosis. In one fortunate case (Pl. XII. fig. 30, *a, b*) a single basal has been preserved, adhering to the centrodorsal piece; and though its outer end is quite inconspicuous, it is relatively larger than the outer end of the basal ray in either of the recent species represented in Pl. XII. There are various other Cretaceous species with larger or smaller basals; but there are also a few of the *Decameros* type without external basals, such as *Hertha* (*Antedon*) *mystica* and *Act. Lovéni*. The latter species has such a striking resemblance to recent *Actinometra* that I suspect it had a rosette; and the same may perhaps have been the case with *Ant. mystica* and with the two Tertiary species *Ant. italica* and *Ant. alticeps*. These are the only Tertiary *Comatulæ* of which the calyx is known; but they may, of course, have had concealed *Pentacrinus*-like basals and no rosette.

In all recent *Comatulæ* (*Comaster* perhaps excepted) the basals which appear externally are not the embryonic basals at all, but only additional elements in the calyx\*, which become connected with the central rosette produced by the metamorphosis of the embryonic basals. Pl. XII. contains some figures of the calices of a few recent *Comatulæ*, to show these basal rays and their connexion with the rosette. They are very well seen in *Ant. macrocnema* from Sydney Harbour (Pl. XII. fig. 25 *c*), which has more resemblance to the Jurassic *Ant. costata* (Pl. IX. figs. 1, 2) than any other recent species. A comparison of fig. 25 *c* on Pl. XII. with fig. 9 *b* on Pl. IX. and fig. 21 *b* on Pl. XI. will show the points of resemblance and difference between the rosette and its appendages in recent *Comatulæ* and the (probably) unmetamorphosed basals of *Pentacrinus* and of fossil *Comatulæ*. Fig. 29 *b* on Pl. XII. shows the corresponding parts of *Ant. antarctica*, in which the basal rays only just appear externally (fig. 29 *a*). The same is the case in the large *Actinometra* represented in fig. 26, and in the smaller *Act. lineata*, shown in figs. 27 *a* and 27 *b*. These two last figures are very instructive. Fig. 27 *b* is a view of the calyx from above after removal of three of the

\* *Actinometra*, pp. 96-104.



radials and of one basal ray. The two remaining radials have almost horizontal ventral faces, with the usual radial and inter-radial furrows. In the centre is seen the rosette from which one basal ray extends N.E.-wards, with a shallow excavation at its central end. Its fellow pointing N. has been removed so as to expose the basal groove of the centrodorsal, in which it was received. The side view (fig. 27 *a*) should be compared with Pl. IX. fig. 6 *c*. The different positions of the articular surfaces of the radials in *Antedon* and *Actinometra* respectively are then well seen. In the former they are inclined at a considerable angle (fig. 6 *c*), whereas in the latter they are generally nearly or quite vertical, as in fig. 27 *a*. Both figures also show the descent of the ventral interrarial furrows into the interior of the calyx. In *Act. lineata* (fig. 27 *a*) they end blindly in the excavated central ends of the basal rays\*. These parts have a singular resemblance to the basals of *Ant. canaliculata* (fig. 6 *c*); but I believe the resemblance to be one of analogy only, and not of homology. If the basals of *Ant. canaliculata* are what I imagine them to be, viz. the original unmetamorphosed embryonic basals, they are homologous, not with the basal rays, but with the central rosette of *Act. lineata*, which is absent in *Ant. canaliculata*.

All the above-mentioned figures of recent *Comatulæ* are essentially similar to those on plates IV.-VI. of my *Actinometra* memoir. Fig. 28, however, represents the calyx of a new and very interesting type, *Promachocrinus*, the chief novelty among the 'Challenger' *Comatulæ*. It has ten radials instead of only five; but there is no corresponding duplication of the rays of the basal star. Only five rays extend outwards from the central rosette to appear externally beneath five of the radials, and they must therefore be regarded as representing the primary interrarii of the type. Hence those radial pieces which are not separated from the centrodorsal by basal rays are the original embryonic radials, homologous with those of the other Crinoids and of the five-rayed Starfishes. The five others may perhaps be compared to the additional radials developed in many-armed Starfishes, in which, however, the positions of the five primary rays are not indicated in the adult as they are in *Promachocrinus*.

The conclusions to which we have been led may be summed up as follows:—

1. In all the Jurassic and in some, at any rate, of the Creta-

\* Compare *Actinometra*, pp. 97-103.



ceous *Comatulæ*, the basals are the embryonic basals which have undergone no further modification than those of many *Pentacrinus* species. Their relative size is reduced, as they do not quite separate the radials from the top stem-joint, even when they appear externally, which is not always the case, both individuals and species varying greatly in this respect.

2. In all the recent *Comatulæ* (possibly also in the Tertiary and in some Cretaceous species) the embryonic basals undergo an extensive modification resulting in the formation of a rosette. In many cases basal rays extend outwards from this and may appear externally; but they are only analogous and not in any way homologous to the true basals of the older *Comatulæ*.

3. Most *Pentacrinini* have a more or less complete circlet of basals separating the top stem-joint, either partially or wholly, from the radial pentagon. But in some few fossil forms there are no external basals, as may be also the case in *Encrinus*. There is thus a parallel variation to that occurring in *Comatula*, but with a different range, for we know of no *Comatula* (recent or fossil) in which the basal circlet is complete, and of no recent *Pentacrinus* in which no basals appear externally.

4. The variations in the development of the basals are useless as generic distinctions. *P. Fisheri*, *P. briareus*, and *P. Sigmaringensis* among the fossil forms, with the recent *P. asteria* and *P. Wyville-Thomsoni*, are all equally good species of *Pentacrinus*. In the same way *Ant. costata* with small basals, *Ant. scrobiculata* with large ones, and *Comatulina* or *Decameros* with none visible externally are just as good species of *Antedon* as *Ant. rosacea*, which has only a rosette, and *Ant. macrocnema*, which has basal rays as well.

Schlüter, therefore, was perfectly justified in uniting *Solano-crinus* with *Antedon*. He does the same with *Comaster*, though from Goldfuss's description of this type it appears to me to differ so much from all other *Comatulæ* that I prefer, for the present, at any rate, to regard it as generically distinct from the other *Comatulæ*\*.

In conclusion, I desire to record my obligations to Prof. Hughes, and to Dr. H. Woodward, F.R.S., and Mr. R. Etheridge, jun., for the readiness with which they have permitted me to examine specimens in the Woodwardian and British Museums

\* See Journ. Linn. Soc. Zool. vol. xiii. pp. 454-456.

respectively. I am also greatly indebted to the Rev. P. B. Brodie, M.A., F.G.S., who kindly sent me *Act. cheltonensis* for description; and I take this opportunity of expressing my thanks to all these gentlemen.

## EXPLANATION OF THE PLATES.

## PLATE IX.

Figs. 1 and 2, *Ant. costata* = *Solanocrinus costatus*, Goldf., from Nattheim. *a*, from the side; *b*, from above.

Fig. 1. Copied from Goldfuss.

Fig. 2. From a specimen in the Woodwardian Museum,  $\times 2$ .

Fig. 3. *Ant. truncata*, n. sp., from Nattheim; side view,  $\times 4$ . British Museum.

Figs. 4 and 5. Different forms of *Ant. costata* (?), Quenstedt ('Der Jura,' pl. 88. figs. 9, 10).

Fig. 6. *Ant. canaliculata*, n. sp., from Nattheim,  $\times 2$ . *a*, *b*, side views of exterior of calyx (*a* without, and *b* with an external basal); *c*, side view of interior, two radials having been removed. British Museum.

7. *Act. wurtembergica*, n. sp., from Nattheim,  $\times 2$ . *a*, from side; *b*, from above. Woodwardian Museum.

8. *Ant. d'Orbigny*, n. sp., from Nattheim,  $\times 3$ . Side views:—*a*, radials showing no outer dorsal surface; *b*, dorsal surface of radials turned up at the angle of the calyx so as to appear externally. British Museum.

9. *Ant. complanata*, n. sp., from Nattheim,  $\times 3$ . Radials and basals only: *a*, from side; *b*, from beneath. British Museum.

## PLATE X.

Fig. 10. *Ant. Tessoni*, n. sp., from side,  $\times 3$ . Argile de Dives, Vache Noire, France. British Museum.

11. *Ant. decameros*, n. sp., from side,  $\times 3$ . White Jura,  $\epsilon$ , Nattheim. British Museum.

Figs. 12, 13. *Ant. depressa*, n. sp., from Nattheim.

Fig. 12. Side view,  $\times 4$ .

Fig. 13. Another specimen, seen from dorsal side,  $\times 5$ .

14–18. *Ant. scrobiculata* = *Solanocrinus scrobiculatus*, Goldf.

Figs. 14, 15. Side views of two specimens, copied from Goldfuss.

Fig. 16. Copy of Münster's figure of a specimen described by him as *S. Bronnii*, but referred by Quenstedt to *S. scrobiculatus*.

Figs. 17, 18. Two specimens from Streitberg, in the Woodwardian Museum,  $\times 4$ . Fig. 17, *a*, from above; *b*, from side. Fig. 18. Radials and basals only: *a*, from side; *b*, from beneath.

## PLATE XI.

Fig. 19. *Ant. aspera*, Quenstedt, sp. White Jura and Streitberg. *a*, from the side; *b*, from above; *c*, from beneath:  $\times 4$ . Woodwardian Museum.



- Fig. 20. *Act. cheltonensis*, n. sp. Inferior Oolite, Cheltenham. Radials and basals only,  $\times 4$ : *a*, from the side; *b*, from beneath.
21. *Pentacrinus asteria*. From Barbadoes. Calyx,  $\times 4$ : *a*, from side; *b*, from beneath.
22. *Solanocrinus Jaegeri*, Quenstedt. *a*, from side; *b*, from beneath. Copied from Quenstedt.
23. *Pentacrinus Wyville-Thomsoni*. North Atlantic. Calyx,  $\times 3$ : *a*, from side; *b*, from above; *c*, from beneath.
24. *Pentacrinus Jaegeri* = *Solanocrinus Jaegeri*, Goldf.: *a*, from side; *b*, from above; *c*, from beneath. Copied from Goldfuss.

## PLATE XII.

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- Fig. 25. *Ant. macrocnema*. Sydney Harbour. Calyx,  $\times 6$ : *a*, from side; *b*, from above; *c*, radials and basals from beneath.
26. *Act. stelligera*, n. sp. Pacific (Stat. 174). Calyx from side,  $\times 6$ .
27. *Act. lineata*, n. sp. Bahia. Centrodorsal with two radials, rosette, and part of basal star,  $\times$ : *6a*, side view of interior of calyx; *b*, the same, seen from above.
28. *Promachocrinus kerguelensis*, n. sp. Balfour Bay, Kerguelen. Calyx from side,  $\times 6$ .
29. *Ant. antarctica*, n. sp. Heard Island. *a*, calyx from side; *b*, radials and basals from below:  $\times 6$ .
30. *Ant. Lundgreni*. From the Upper Chalk, Margate. Centrodorsal with one basal attached,  $\times 3$ : *a*, from side; *b*, from above.

MOLLUSCA OF H.M.S. 'CHALLENGER' EXPEDITION.—Part VI.  
By the Rev. ROBERT BOOG WATSON, B.A., F.R.S.E., F.L.S., &c.

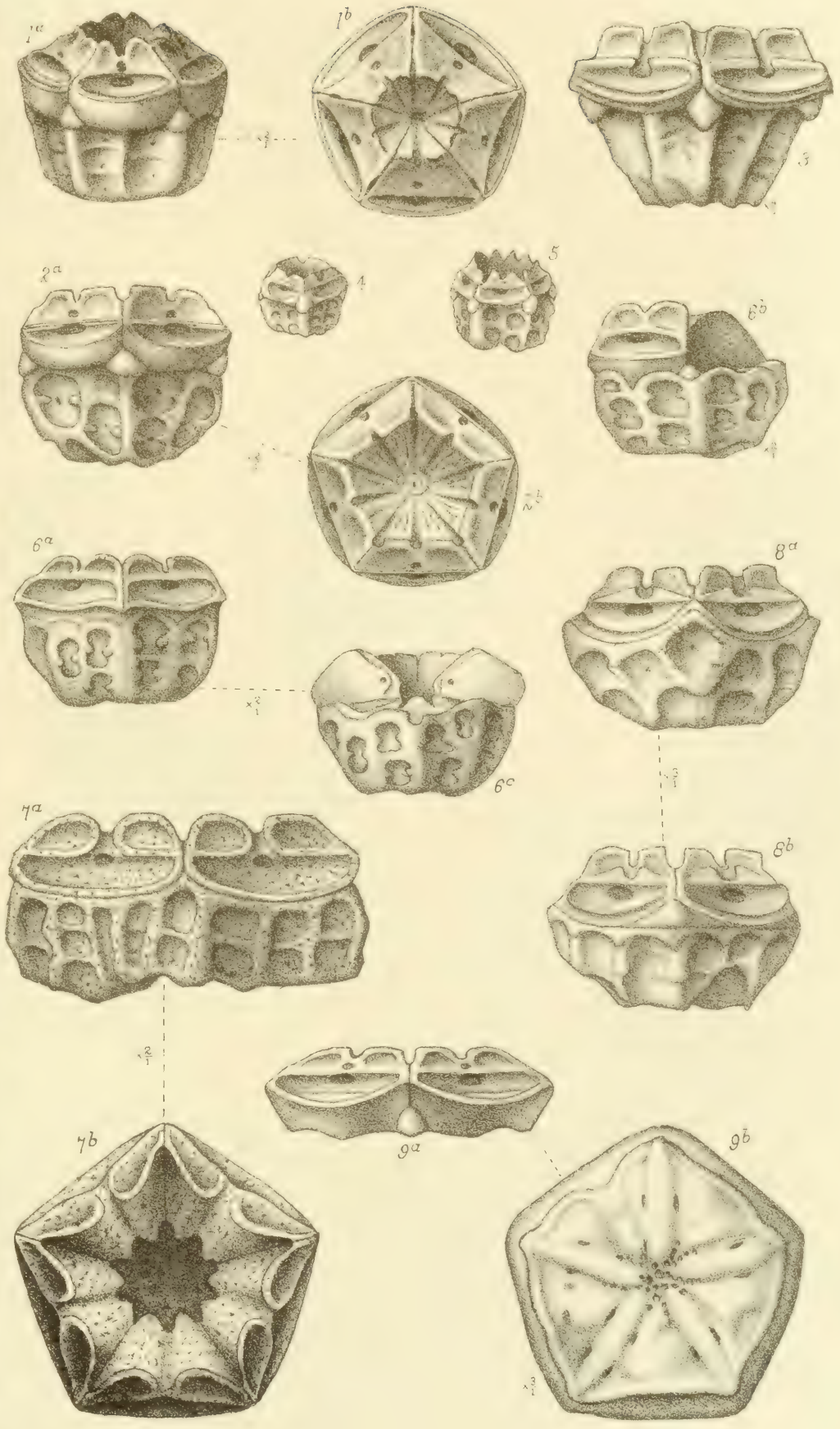
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[Read April 15, 1880.]

## TURRITELLIDÆ, n. sp.

- |                          |                           |
|--------------------------|---------------------------|
| 1. TURRITELLA RUNCINATA. | 6. TURRITELLA AUSTRINA.   |
| 2. — ACCISA.             | 7. — DELICIOSA.           |
| 3. — CARLOTTÆ.           | 8. — (TORCULA) ADMIRA-    |
| 4. — PHILIPPENSIS.       | BILIS.                    |
| 5. — CORDISMEI.          | 9. — (TORCULA) LAMELLOSA. |

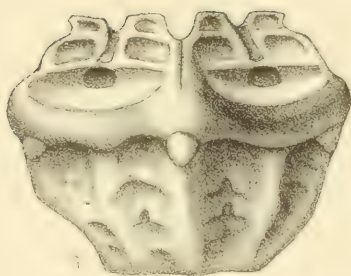
The genus *Turritella* is a group well defined, as regards the shell, the animal, and the operculum; nor is it unmanageably large. There is therefore no *primâ facie* reason for breaking it up as Gray has done; and his destructive process has not justified itself in the characters of the genera he proposed, which are







11



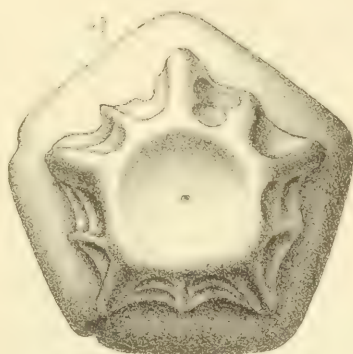
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14



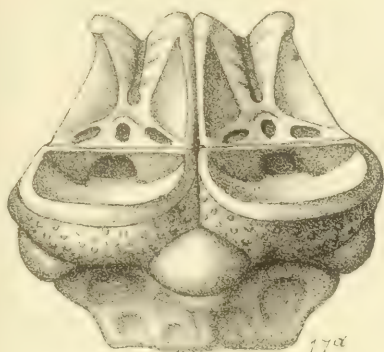
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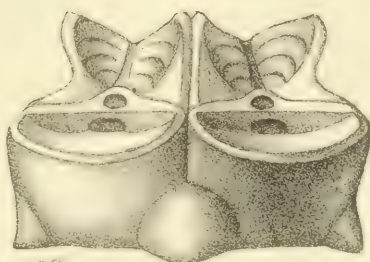
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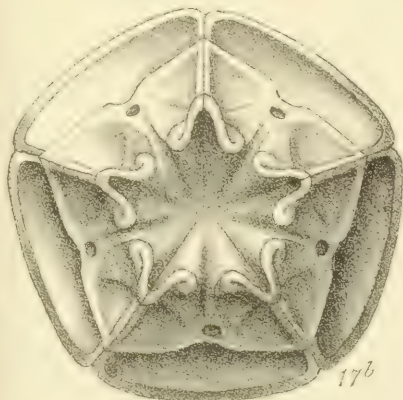
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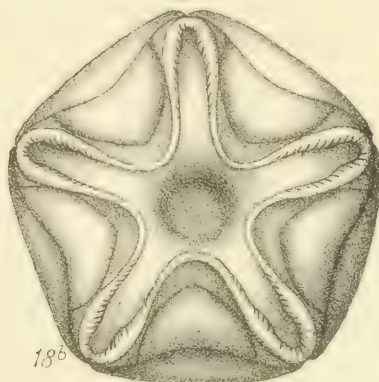
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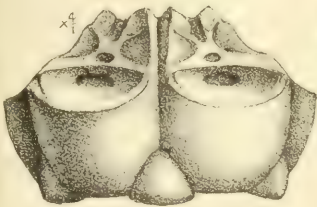
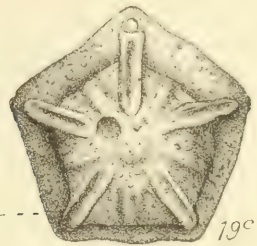
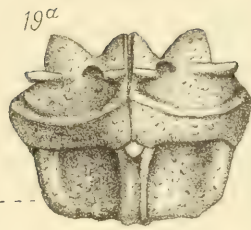
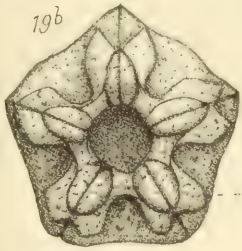
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17<sup>b</sup>

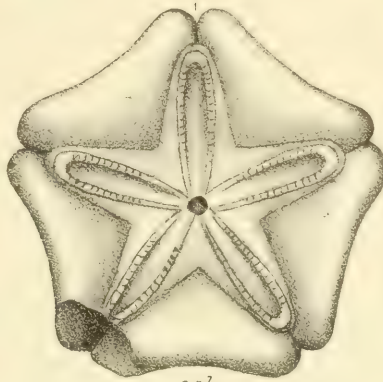


18<sup>b</sup>



21a

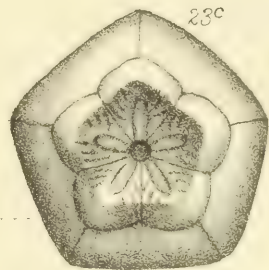
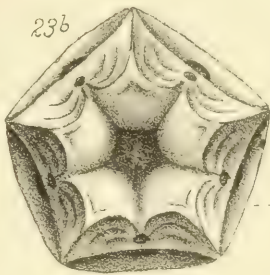
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22a

22b

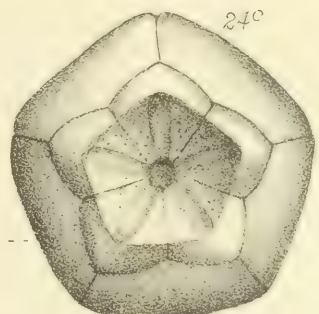
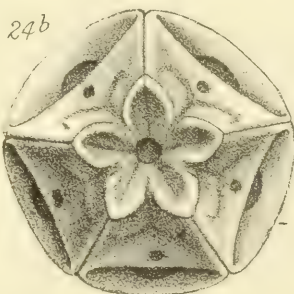
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23b

23a

23c

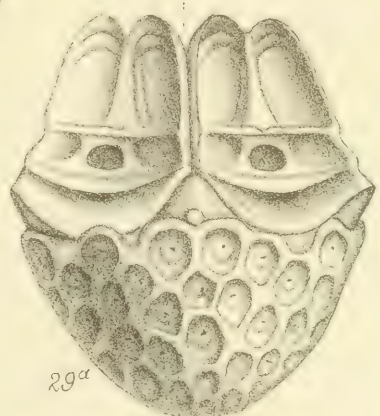
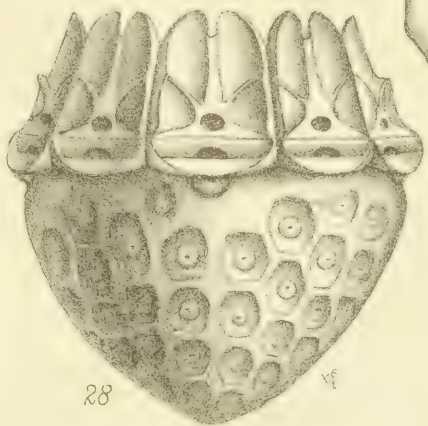
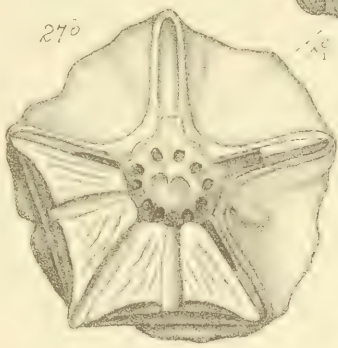
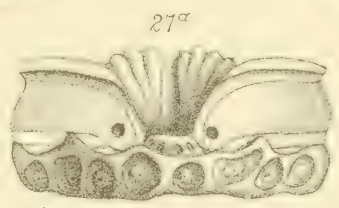
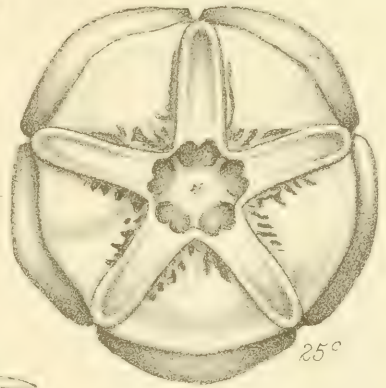
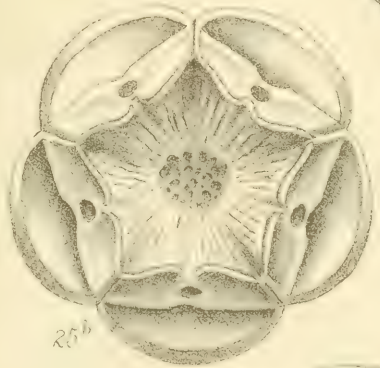
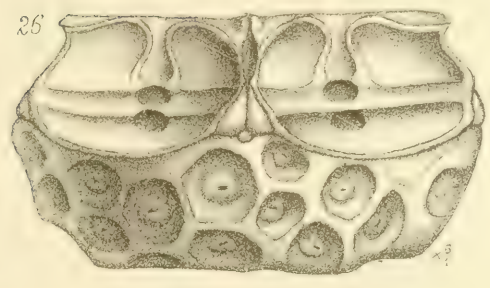
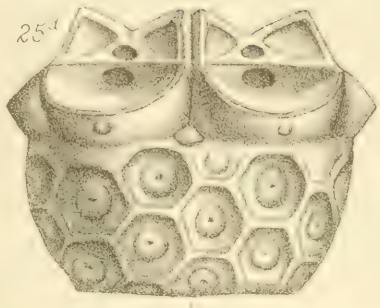


24b

24a

24c





"CHALLENGER" SPECIES OF ANTEDON, ACTINOMETRA, & PROMACHOCRINUS.